Universal Design in Playground Environments: A Place-Based Evaluation of Amenities, Use, and Physical Activity

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ABSTRACT This study compares three playground environments for the impact of Universal Design on playground use and the physical activity levels of users. While Universal Design principles are increasingly used in playground design, most prior work has focused on their roles for people with disabilities. This study explores Universal Design impacts on all users regardless of their age or disability status, applying a case-comparison methodology with one case playground (built with Universal Design principles) and two comparison playgrounds (built without Universal Design principles) that are comparable in other conditions. Using a modified System for Observing Play and Recreation in Communities tool that enables location-specific recordings of momentary environmental observation data, this study compares use and physical activity in playground environments. User location and characteristics were recorded on a plan map of the park and the playground. The data were collected from 70 randomized observation periods per park (210 total for the three parks) recording 12,520 total users. Results showed that while the total user counts were similar across the three parks, the Universal Design playground showed 82% more users than in the mean of the comparison playgrounds. The study also applied methodologies serving to evaluate the place-based effects of park elements on the intensity of park use and physical activity. The playground areas produced 46% of park use, with the highest percentages of active use (29.2%) in the parks as a whole demonstrating the contribution playground environments make to overall park use and physical activity.

KEYWORDS Children, play, accessibility, environmental observation, behavior analysis

BACKGROUND AND SIGNIFICANCE

A growing body of evidence affirms that high-quality parks in a community promote active lifestyles, encouraging physical activity (PA) in children and other members of the community (Hunter et al., 2015; Molina-García et al., 2021). Play environments in public parks and neighborhoods have a key role in encouraging people of all ages and abilities to get outdoors and be active (Cohen et al., 2020; Lee et al., 2013; Molina-García et al., 2021; Moore & Marcus, 2008; Mowen, 2010; Sallis et al., 2015; Silver et al., 2014; Van Dyck et al., 2013; Zhou et al., 2016). Increased PA positively impacts quality of life by improving physical and mental health; evidence shows that parks and recreational settings contribute to overall healthcare outcomes (Colabianchi et al., 2011; Kaczynski et al., 2008; Valentini & Morosetti, 2021). Access to and availability of facilities and time spent outdoors in the built environment are positively correlated with PA in children in a diversity of socioeconomic conditions (Escaron et al., 2019; Raney et al., 2019; Sallis et al., 2015). Many have called for more research on the specific physical elements of the outdoor environment that can guide policy and lead to strengthened design interventions supporting the health and socialization benefits of getting more people of all abilities outdoors and active (Chow et al., 2016; Cohen et al., 2020; Colabianchi et al., 2011; Costigan et al., 2017; Graham et al., 2021; Kaczynski & Henderson, 2008; Koohsari et al., 2015; Moore & Marcus, 2008; Mowen et al., 2013; Perry et al., 2018).

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Researchers have argued for the inclusion of people of all abilities in play environments (Kodjebacheva et al., 2015; Lynch et al., 2020; Moore et al., 2022; Saitta et al., 2019; Wenger et al., 2022). The need for social inclusion of people of all abilities was formalized by the Americans with Disabilities Act (ADA) of 1990, from which initiatives on inclusion and removing barriers to inclusion have become an important consideration in the outdoor environment and playgrounds. Implementation is specified in the 2010 ADA Standards for Accessible Design (United States, 2010), commonly referred to as the ADA Standards. An important element of play and the play environment for children is that they facilitate communication and interaction with peers, allowing them to engage in a variety of play behaviors with other users. In other words, they serve children by acting as both a social space and a space for healthy PA (LeSchofs, 2020; Moore & Cosco, 2007). Physical disabilities in children are the most commonly thought of and accommodated needs; unfortunately, many playground areas are not fully designed to accommodate children with physical or other kinds of disabilities (Perry et al., 2018; Prellwitz & Skär, 2016; Stanton-Chapman & Schmidt, 2019).

Universal Design (UD) principles are intended to go beyond the minimum requirements of the ADA Standards in an attempt to better accommodate people of all abilities. In recognition of the attempt to design for all, physical access is both the focus of the ADA Standards and the most recognized minimum standard. Equal access to experiences, a standard that is difficult to fully ensure, has been gaining more attention in recent years (Little, 2020). The central principles of UD entail eliminating barriers to social inclusion and interaction in the playground environment and getting children together within the play space. The definition of UD has taken many forms since its first conception by architect Ron Mace (Moore & Cosco, 2007) and an early definition by North Carolina State University ("the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaption or specialized design"). UD has the overall goal of making the built environment as accessible and usable as possible for a diverse population (Story, 2011). In play areas, definitions of UD have included environmental features such as accessible routes, resting and gathering areas, use of sensory stimuli such as plants, and various accessible play features that make play areas more accessible to those with disabilities and those of all abilities (American Society of Landscape Architects, n.d; Goltsman, 2011).

Applications of UD have varied in scope and focus to reflect a diversity of people with different, physical, sensory, and cognitive challenges directing a variety of responses. A common misconception of UD is that it is designed only for those living with a disability (The Universal Design Project, n.d.). The definitions of UD are open-ended, reflecting the diversity of disabilities served, and are by nature difficult to measure quantitatively. Many in the design disciplines have sought to apply the principles of UD in playground environments to better accommodate people of all abilities, shifting a common assumption that inclusive design is limiting (Burke, 2012, 2013; Cohen et al., 2014; Jeanes & Magee, 2012; Lid, 2013, 2016; Ostroff, 2011), and seeking to make playgrounds usable for those of all abilities without the need for adaptation (Goltsman, 2011; Perry et al., 2018; The Universal Design Project, n.d.).

The principles of UD are increasingly applied in playgrounds and have the potential to encourage more use (Moore & Cosco, 2007). There has been some colloquial indication of the possibility that the presence of UD in play environments may have a positive impact on use in those environments (Hurst & Lee, 2014). More formal research is needed to evaluate how park and playground users receive facilities designed applying UD principles (Lynch et al., 2018; Perry et al., 2018). This research aims to offer an intentional investigation of the possibility that UD in playground environments may positively impact use.

The primary aim of this research is to evaluate the outcomes of implementing UD principles in children's play environments by investigating whether playgrounds designed using UD principles are more attractive to the general public than those designed using the ADA Standards as minimums (Goltsman, 2011; Lynch et al., 2018; Moore & Cosco, 2007; Prellwitz & Skär, 2007). The minimums are referred to in this study as Accessible Design (AD), defined in the ADA Standards (United States, 2010). In contrast to AD, UD typically applies unitary accessible play surfaces, ramp access, and increased access to other features both on the play structure and on the ground level that will be operationally defined later in the paper. Measurement of the primary aim was done through behavior observation by comparing differences in observed use. This research uses a Case playground designed with UD principles and two Comparison playgrounds designed in terms of AD to test the hypothesis that a play area designed with UD principles will be more popular as evidenced by more use than those designed meeting AD standards in comparative play environments.

The secondary aim of this study is to explore PA levels associated with specific activity areas in parks and playgrounds with some exploratory questions. Is there evidence of increased PA among users of the playground designed with UD principles compared with playgrounds designed to simply meet the AD requirements? Is there evidence of PA relationships between participants/users and other park and playground physical amenities? Evaluation is done by measuring percentages of active participants/users at each area and translating their PA measurements into metabolic equivalents (METs), a validated measurement of energy expended by participants. This secondary research is exploratory and did not use the more stringent measurements of PA by methods such as heart rate monitors, which require interaction with the participants, but instead sought a validated indication of PA that could be compared between the playgrounds and some of the surrounding park features (Ainsworth et al., 2011; Fjørtoft et al., 2010).

METHODS

This cross-sectional case study investigates the use of a play environment using UD principles compared with those built to meet the minimum AD standards (Leedy et al., 2014). It combines a place-based momentary behavior observation system for evaluation of user activity—based on Thomas McKenzie's validated and widely applied System for Observing Play and Recreation in Communities (SOPARC) protocols, in which observers record participants (their age, gender, and PA levels)—with behavior mapping techniques that record participation in place. Combining these approaches allows the researchers to evaluate human behavior in response to environmental conditions (Cosco et al., 2010; Evenson et al., 2016; McKenzie et al., 2006; Moore & Cosco, 2007). Still, measuring activity and participation does not illuminate the intentions and experiences of those participants. Survey instruments capable of evaluating these variables and other participant qualities were not a part of the study.

Observation data was recorded for users of the playgrounds, comparing use in UD versus AD as the primary aim of the study. Observations of users in the parks were conducted to evaluate for contextual influences of park use on playground use. The overall park data was also used to contribute to the secondary aim of evaluating physical activity in the park as a whole. The recorded activity data were used for both the primary and the secondary aims (Ainsworth et al., 2011).

Study Setting

The study was undertaken in the City of University Park, a suburb of Dallas, Texas. The city, incorporated in 1924, is home to Southern Methodist University and the George W. Bush presidential library. The city as a whole covers 3.69 square miles (approximately 2,360 acres), with an estimated population of 25,078 residents that has increased only 14% since 1990, although its minority population has increased by nearly 20%. The Trust for Public Land rates the city as having 92% of its residents within a 10-minute walk of one of its parks, all of which enjoy a high level of quality maintenance. Observations and data collection were carried out in 3 neighborhood parks located in the city (City of University Park, 2022; U.S. Census Bureau, 2020).

The unique research setting was a purposive selection of three playgrounds in three proximally located neighborhood parks. In many instances, playgrounds built to UD standards are in destination parks that are the feature parks of a city that would naturally attract more use. This study offers a unique set of neighborhood parks that were largely similar in size, amenities, and maintenance to each other. The study evaluated the playground in Coffee Park (the Case, employing UD principles) and the playgrounds in Caruth Park and Curtis Park (Comparison I and Comparison II, respectively, employing minimum AD standards). The park locations shown in Figure 1 allow for a comparison of the three park environments within the city contextual factors that are evaluated in more detail in the discussion of physical features of the study's setting. The unique condition of having UD in a playground in a neighborhood park that is in close proximity to two comparable neighborhood park playgrounds

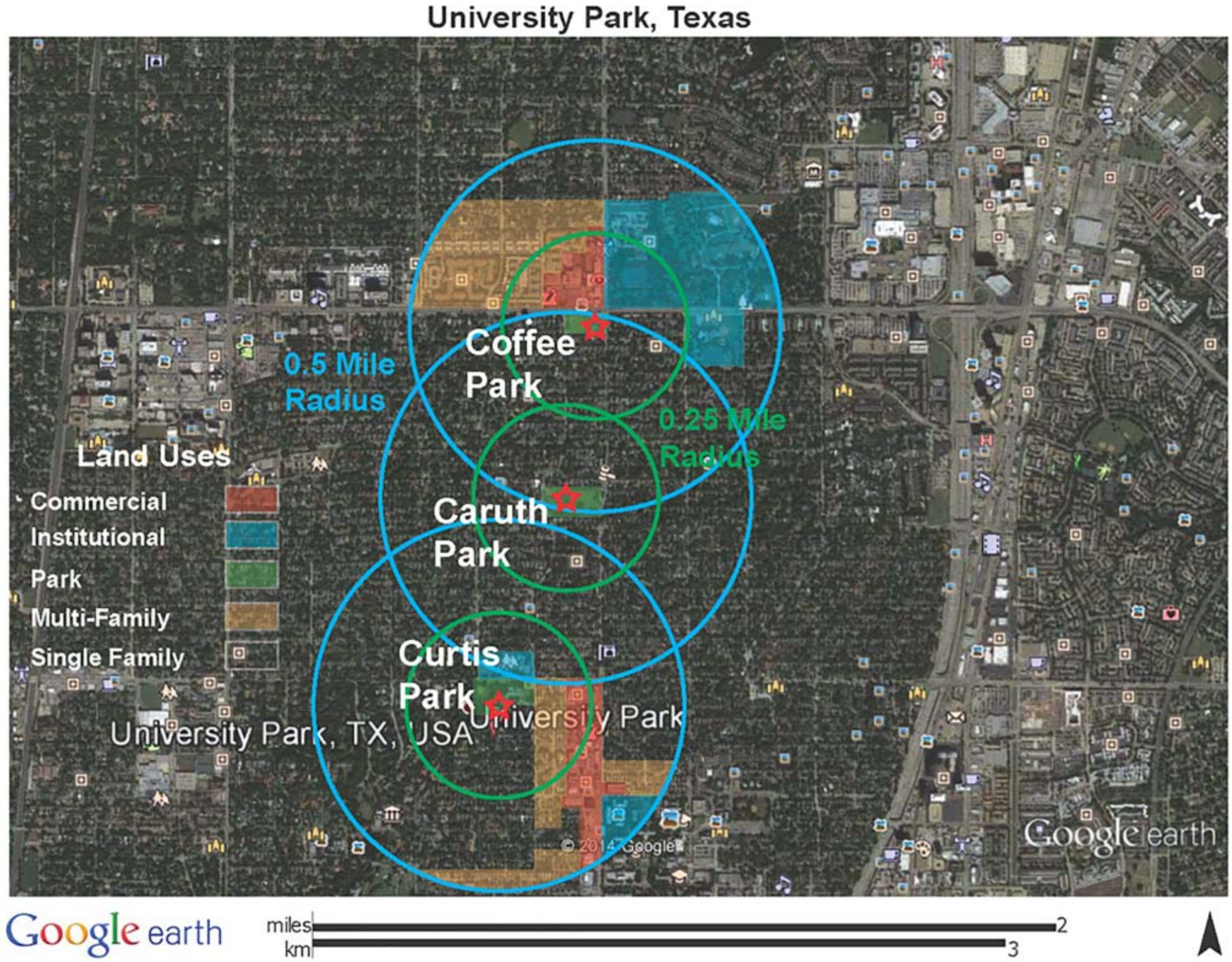

Figure 1
Proximal location and land use of the study's three parks. Graphic by first author. Satellite imagery downloaded from Google Earth 5/16/2014, https://earth.google.com.

allows the study to hold most of the relevant community and park variables at similar levels.

Each of the three parks differs in size, but all are regarded as neighborhood parks having similar levels of park amenities, tree cover, and maintenance practices. The parks were each divided into eight Target Areas (TAs) with similarly defined activities. Each park had two active park areas and two passive park areas making up the Park Zone and two active playground areas and two passive playground areas making up the Playground Zones, as shown in Figure 2. These park and playground TAs were combined into two Zones in each park, the Park Zones represented by TAs 1–4, and the Playground Zones represented by TAs 5–8 (Cosco et al., 2010; McKenzie et al., 2006).

The three playgrounds were of a similar character: each had equipment of the same type and manufacturer, and the surfacing in each of the playgrounds was poured-in-place rubber of the same surface color (a green/black mix). These similarities improved comparability (Figure 3). The Case playground was six years old at the time of the study and had a poured-in-place (PIP) unitary rubber surface, one of the best play surfaces in terms of accessibility. Comparison I and Comparison II playgrounds were older, but two years before the study, they had undergone a renovation that has been shown to raise participation rates (Anthamatten et al., 2014). The comparisons received new PIP surfacing, along with equipment refurbishing and updating that included the installation of new shade roofs matching those

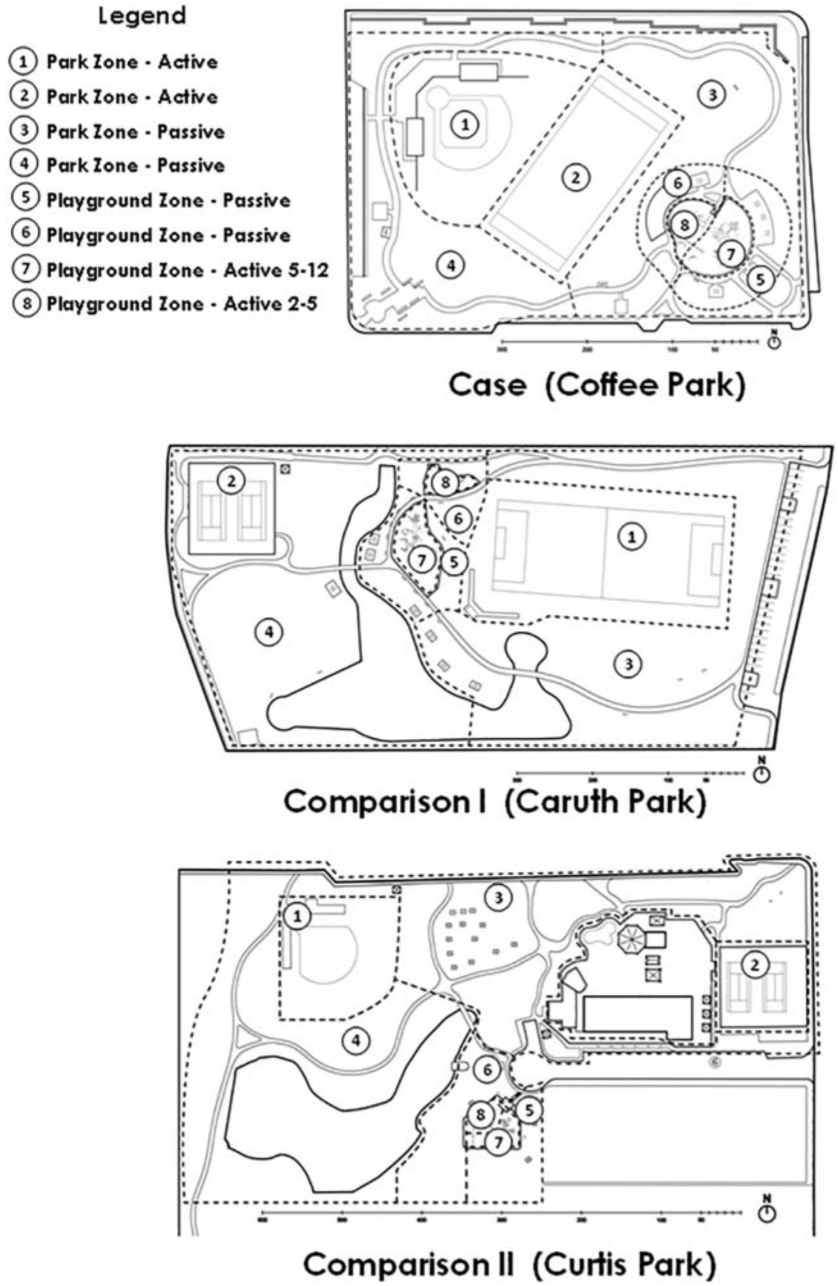

Figure 2
Park and Playground Target Areas (TAs) in the study's three parks. Graphic by Yizhen Ding.

in the Case playground. As a result, the surfacing in each of the playgrounds was unitary, and the equipment was of the same type and manufacture, making the three parks of similar and comparable character.

Study Setting Physical Features

The setting affords a unique opportunity for comparative case study research evaluating the differences in use related to playgrounds' physical qualities in comparative environments of proximally located research sites where many of the potentially confounding elements are at similar levels. Total numbers of physical features; measures of park and playground size; and access to picnic tables, park benches, drinking fountains, toilets, etc. are often considered to be attractive elements concerning park use (Van Dyck et al., 2013). These variables as they relate to the three parks in the study are shown in Table 1 and do not support an advantage in the Case versus Comparison I or Comparison II.

The number of play components such as slides, climbers, and play panels—along with the size of the play surface space—are commonly used to evaluate playground size. The numbers of play components in the Case and Comparison I are similar at 40 and 41,

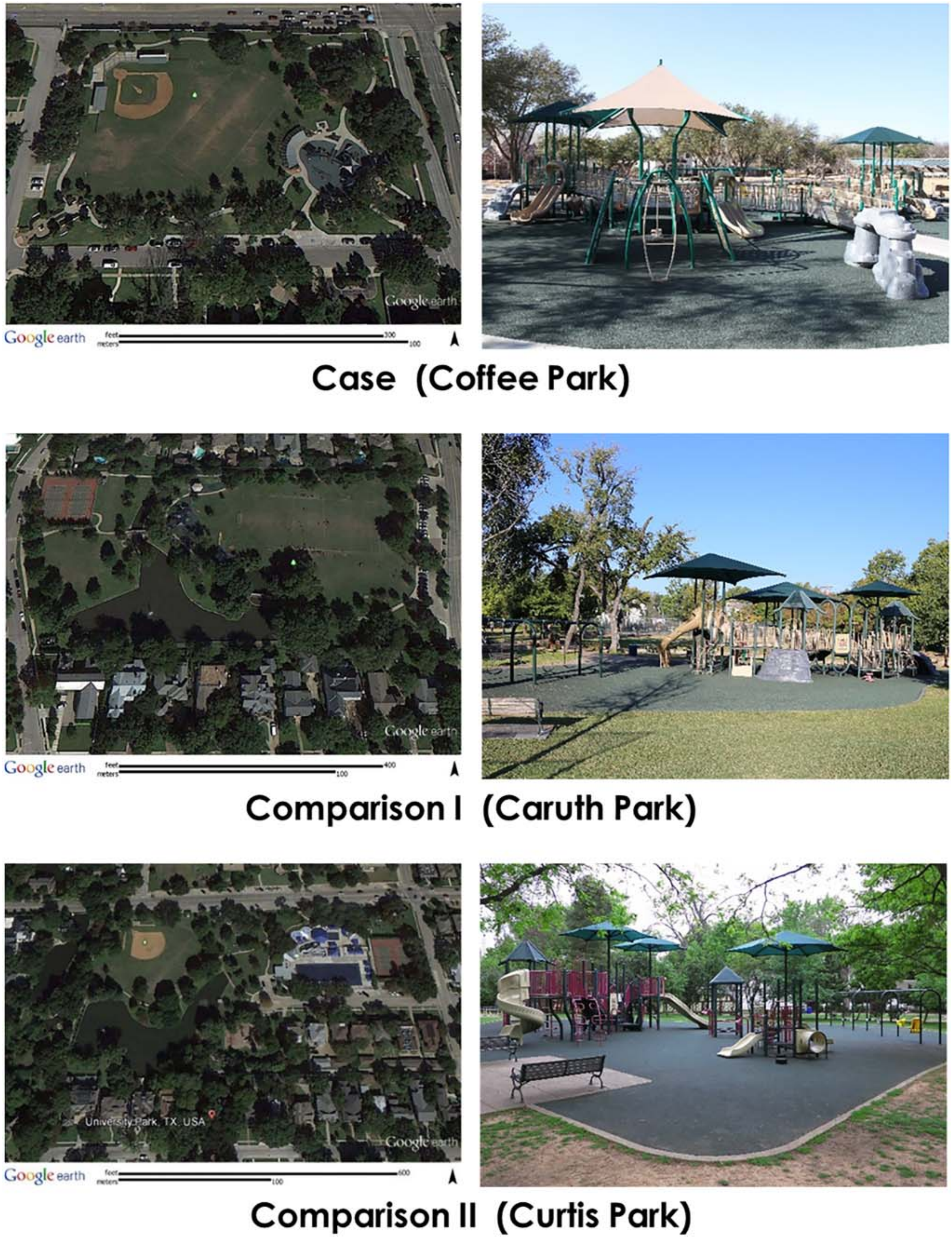

Figure 3
Comparative aerial images of the study's three parks and Playground Area ground-level images. *Park satellite imagery downloaded from Google Earth 5/16/2014, https://earth.google.com. Ground-level photographs by first author.

Table 1. Physical Features: Playground and Park Inventory

Variable	Playground			Park		
	Case	Comp I	Comp II	Case	Comp I	Comp II
Universal Design (UD)	1	0	0			
Play Components	40	41	31			
Playground Surface (s.f.)	6,400	7,900	5,700			
Playground Size (s.f.)	18,800	23,800	31,800			
Shelter Structure	1	0	0			
Toilets	1	1	1	1	1	1
Drinking Fountains	1	0	1	2	2	3
Benches	5	15	5	5	5	12
Picnic Tables	6	6	3	0	1	8
Walking Trail Circuit (ft.)				1,440	1,401	2,084
Park Size (acres)				4.3	7.1	9.5
Tree Canopy Coverage (%)				34	36	44
Water Area (%)				0	13	12
Parking (Car Spaces)				46	44	72
Public Use Athletic Facilities				2	3	2

respectively, but lower in Comparison II, which has only 31. A shelter structure is present in the Case but not in Comparison I or Comparison II. This difference will be evaluated based on the observed use for its potential influence on playground use. These variables as they relate to the three parks in the study are shown in Table 1 and do not support the Case being more attractive than Comparison I or Comparison II. Of the three play environments, the square footage of the play area surfacing in the Case falls between that of Comparison I and Comparison II, and the square footage of the playground environment as a whole is the smallest in the Case. The primary analysis was conducted on the number of users per observation. To adjust proportionally for differences in size, users per play component and users per square foot of surfacing were analyzed separately.

Demographics of the surrounding neighborhoods, such as age profile and the number of housing units within one-quarter-mile and half-mile buffer areas from the center of each park, were found to be comparable (Table 2). The overall population surrounding the three parks was very similar. The numbers of children were slightly higher for the surrounding communities where Comparison I and Comparison II were located, and the mean age and the number of households were higher in the Case neighborhood. There also were higher percentages of commercial and institutional land uses in the Case neighborhood.

Operationalizing UD

A working model is needed to translate UD into a set of measurable design principles in the play environment (Lynch et al., 2018; Moore et al., 2022). Therefore, a quantifiable operational definition of UD in playgrounds was applied in this research. The 2010 ADA Standards for Accessible Design in Section 240 specify that playgrounds must have an accessible route and accessible surfacing, and 50%

Table 2. Neighborhood Demographics and Land Use

Variable	¼ Mile Area			½ Mile Area		
	Case	Comp I	Comp II	Case	Comp I	Comp II
	Coffee	Caruth	Curtis	Coffee	Caruth	Curtis
Demographics (Estimated 2015)						
Total Population	1,276	1,199	1,335	4,559	5,240	5,318
Age 0–9 Years	175	187	169	571	815	675
Age 10–19 Years	188	255	225	649	1,113	1,020
Age 20+ Years	911	758	941	3,340	3,311	3,622
Total Households	573	379	510	2,041	1,621	1,971
Median Age	45.1	40.9	36.8	46.3	40.9	35
Percent Land Use (%)						
Park	3.6	5.4	7.5	1.7	2.1	1.8
Commercial	11.7	0	6.0	3.1	0.1	5.7
Institutional	17.4	0	4.5	18.4	0.8	2.9
Multi-Family Residential	9	0	12.0	13.6	0.1	8.7
Single Family Residential	58.3	94.6	70.0	63.2	98.7	80.9

Source: Esri Demographic and Income Comparison Profile, December 10, 2015.U.S. Census Bureau, Census 2010 Summary File 1. Esri forecasts for 2015 and 2020.

of the play components must be located on the accessible route. Specifications must be met for transfer access and ramp access of elevated equipment, and also for ground-level components based on numbers of elevated components (United States, 2010).

For the playground to be considered UD by the operational definition, all surfacing must be of a unitary type (rubber tile or poured-in-place). In addition, 100% of the elevated play components that are typically part of a modular play structure must be on the accessible route (50% are required by the ADA Standards), and 50% of elevated components must be ramp accessible (25% are required by the ADA Standards after the minimum threshold of 19 elevated play components). The ADA Standards also require a specified number of ground-level play components that are approached and exited at the ground level. Some examples include swings, spring rockers, play panels, and free-standing components. For this definition of UD, there should be twice the number and types of ground-level play components as those required by the ADA Standards. This definition of UD essentially doubles the minimum requirements of the ADA Standards. An evaluation of the elevated and ground-level play components of the three playgrounds in terms of section 240 is presented in Table 3 (United States, 2010).

The presence of unitary poured-in-place surfacing in all 3 playgrounds makes the surfacing type a constant and a controlled research variable. All of the playgrounds meet the minimum ADA Standards for play components on an accessible route and for ground-level play components in both quantity and type. Only the Case has ramp access and meets the UD's 50% ramp access definition for both 2–5-year-old equipment and 5–12-year-old equipment. All of the remaining elevated play components of the Case have an elevated accessible transfer station and stair sequences, locating all (100%) of the play features along an accessible route. Figure 4 shows a common

Table 3. Accessible Play Component Analysis

Park	Age Group	Total Elevated Events	Ramp Access	Transfer Access	Required* Ground Level Events		Provided* Ground Level Events	
					No.*	Type*	No.	Type
Case	2–5	9	7	2	3	3	7	3
	5–12	14	7	7	5	3	10	7
	Total	23	14	9	8	4	17	8
Comparison I	2–5	8	0	8	3	3	6	3
	5–12	18	0	18	6	3	9	4
	Total	NA**						
Comparison II	2–5	6	0	6	2	2	4	3
	5–12	12	0	12	4	3	9	4
	Total	NA**						

* From Table 240.2.1.2, 2010 ADA Standards for Accessible Design.
** Not applicable because the structures are separated.

Figure 4
Transfer stations—ground level (above) and elevated (below). Photographs by first author.

ground level transfer station and two elevated transfer stations at the Case playground meant to provide a way for individuals using a wheelchair to transfer to elevated play components. The Case playground has 17 ground-level play components of 8 types, representing at least twice the ADA minimum requirements of 8 events of 4 types. In the Case playground, all of the elevated play components are on unitary surfacing and an accessible route, and 50% are ramp accessible. Twice the required number of ground-level play components are present, meeting the operational definition of UD, while the two comparison playgrounds meet the ADA minimum requirements (United States, 2010).

Study Variables

For the primary aim, the independent variable is the presence (Case) or absence (Comparison I and Comparison II) of UD in the playground. The dependent variable is the number of users observed in the playground environments, with the number of users in the parks overall as the mediator. The main outcome of the exploratory secondary aim is the estimated PA levels derived from the field observations using a unique set of symbols based on participants' age, gender, and PA levels (Cosco et al., 2010; McKenzie & Cohen, 2006). The field observation included the recordings of age estimated as preschool (0–4), school-age (5–12), teen (13–19), or adult (20+), gender (male/female), and the PA levels as either sedentary (lying down, sitting, standing) or active (walking, running, jumping, climbing, sliding, swinging) (Cosco et al., 2010; McKenzie et al., 2006). The age groups are selected based on playground industry practices and are consistent with U.S. playground safety standards (*Public playground safety handbook*, 2010).

Observation Protocols

Observed user data were recorded in the playgrounds to evaluate users' primary aims and, in the entire parks surrounding the playgrounds, to investigate if use levels in the surrounding parks might influence use in the playgrounds located within each park. Momentary activity observations were performed following SOPARC protocols, with the parks and playgrounds being divided into Target Areas (TAs). The subjects were recorded graphically on paper plans of the parks and playgrounds (McKenzie et al., 2006) using a unique set of 16 symbols created for this research to categorize the observed person's age, gender, and PA level. The observer walked the same route in the process of making observations in each park and each playground, recording the location of each user with a single symbol that identified age, gender, and PA levels at the moment it was observed (Figure 5). On each day of the observations, the police department was notified of the presence of researchers in the public parks. All the study protocols and instruments were approved by the University Institutional Review Board (IRB).

Field Observation Times

The 5 observation periods used each day in this study had starting times of 7:30 a.m., 9:30 a.m., 12:30 p.m., 3:30 p.m., and 6:30 p.m. Two rotations of observations were conducted during each period and then averaged for a single number of users observed for each period. Observations were consistent with SOPARC and performed during daylight and clement weather conditions (McKenzie et al., 2006). The 14 observation days were organized into 2 sets of 7 days, with each set in 1 of 2 periods of 3 weeks between March and May 2015. In each set, 1 day was chosen for each day of the week, then randomly chosen from a 3-week period. The observation days were systematically randomized, with 2 days observed for each day of the week and weekend, Sunday through Saturday. On 3 days, rain made conditions unfavorable for both park use and observation recording. They were rescheduled and conducted on the same day 1 week later. The total number of observation periods was 70 per park (5 observations per day, 14 days) for a total of 210 observation periods across the 3 parks. The 5 observations per day and 14 observation days exceeded the mean numbers of observations (4.3) and days (6.5) in the 24 studies using SOPARC cited by Evenson (Evenson et al., 2016).

Data Collection

The investigators were trained by a thorough review of the existing written training material on the momentary observation protocols used in SOPARC (McKenzie & Cohen, 2006; McKenzie et al., 2006). Preliminary trials found that in playgrounds,

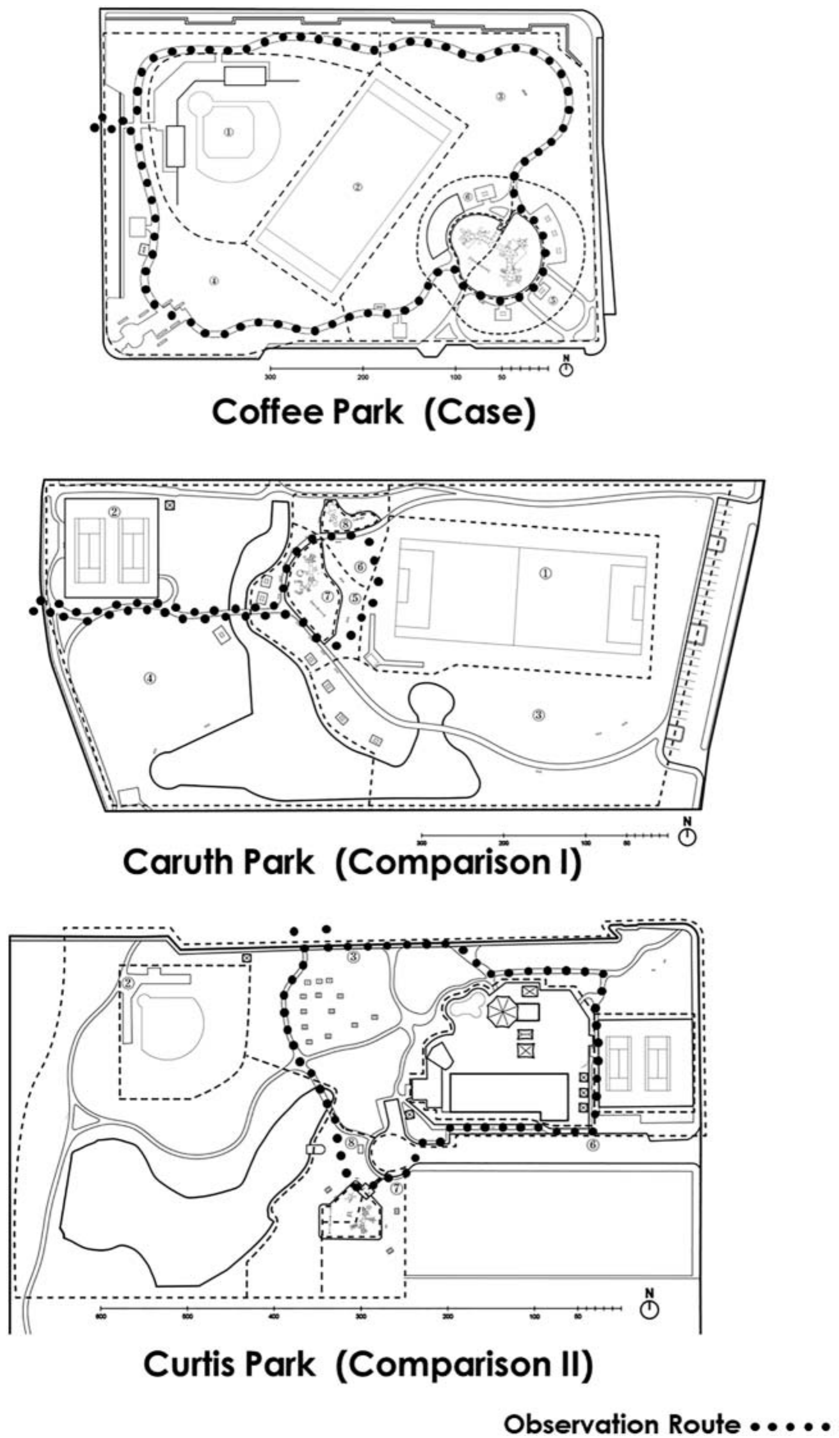

Figure 5
Observation routes in the study's three parks. Graphic by Yizhen Ding.

differentiating between low PA levels (walking) and moderate to vigorous PA levels was difficult because of the high numbers of subjects and the dynamics of changing paces of the active players. The low, moderate, and vigorous PA levels were combined in this study into a singular level termed "active" and contrasted with "sedentary" (sitting, standing, or lying down) for the PA recording. The trials confirmed that observations (including a 2nd rotation of the observation period) at each of the 3 parks could generally be conducted within approximately 60 minutes, taking into account the travel time between parks.

Recording the observed subjects was done using an 11" × 17" plan of each park and playground zone showing features, accommodations, TAs, and walkways on these plans, applying the new graphic

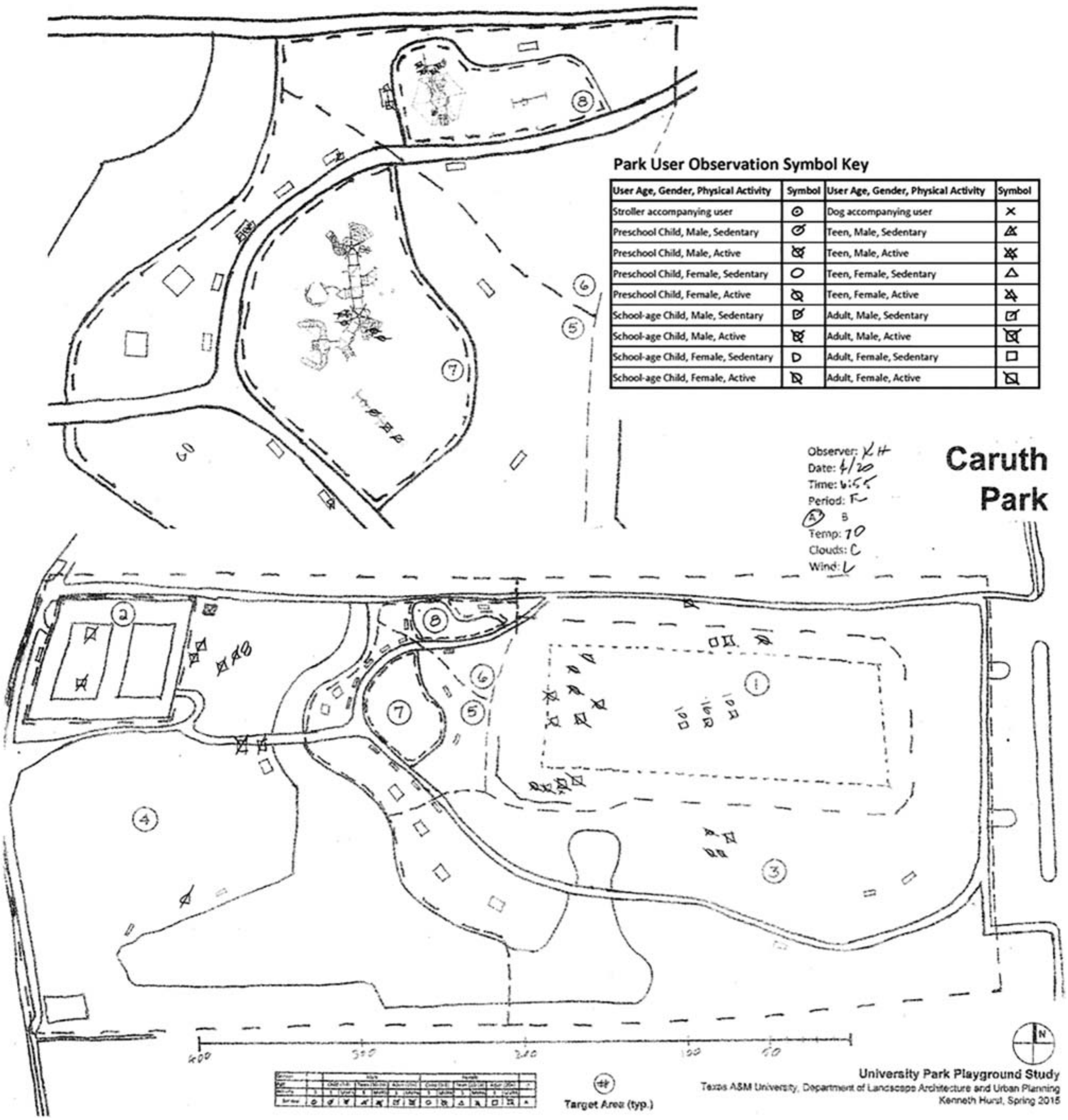

Figure 6
Sample of completed observations in the Playground Zones and in the overall Park Zones in Comparison II with graphic symbol key. Graphics by first author.

symbols developed specifically for this research in the locations of observed users. An example of completed sheets of Comparison II for one observation, along with the graphic symbols, is shown in Figure 6. The symbols reflect the 16 variables representing the subject's age, gender, and PA level. Two additional symbols for children in strollers and dogs seen in the parks are included. People using mobility assistive devices are indicated by filling in the shape symbol within each of the 16 categories.

Inter-rater Reliability

An inter-rater reliability assessment was carried out to understand the reliability of this observation instrument. During the 1st day of the research observations, a 2nd observer conducted parallel observations. The 2 observers walked the same route through the parks and independently completed the recordings. Observations were made at each of the 3 parks, during 5 time periods, with 2 rotations per period resulting in 30 separate observations for each observer. A one-way random-effects model was used to evaluate the correlation between observers in 8 separate TAs during each observation, resulting in a total of 240 TAs. The Interclass Correlation Coefficient (ICC) values showed a high level of agreement, with all values over 0.99 ($F = 1761.42$, $p < 0.001$). This level of agreement gave strong support for high inter-rater reliability (StataCorp, 2013).

Data Analysis

Each of the 3 parks in the study were divided into similarly structured Park Zones and Playground Zones, composed of 4 TAs (8 TAs per park). For the primary aim, the unit of analysis is each observation period where there were 14 observation days, with 5 observation periods per day per park ($n = 70$ per park, $n = 210$ overall). Overall use is converted into users per observation to evaluate whether playground environments designed using UD principles are more popular than those using only AD standards.

Simple descriptive statistics reported overall use divided into age, gender, and PA in the Park Zones and Playground Zones. Analysis of variance (ANOVA) statistics were used to test the significance of the use difference between use levels in the case designed with UD and each of the two comparisons without UD (Acock, 2008). The effect size of UD was estimated statistically by regression using zero-inflated negative binomial regression (ZINB) given the nature of the outcome variable as a count variable with a significant number of zero values (Long & Freese, 2014). Further exploratory analyses were conducted with graphs and plans, and by comparing the data across use areas within each zone.

For the secondary aims, a descriptive analysis of use and PA levels relative to specific amenities was carried out first. The evaluation included a graphic presentation of overall use during a representative day in each of the parks overall and in specific playground environments, showing where users tend to congregate. Finally, PA was evaluated in the Park and Playground Zones using Metabolic Equivalents (Ainsworth et al., 2011).

RESULTS

Recording users' locations on a plan of the site enabled specific evaluation of place-based use in the Park Zones and Playground Zones, as was done in SOPARC, and provided the ability to evaluate use by park element and affordance. The term "affordance" was used in a theoretical sense by the psychologist James Gibson to denote properties of the physical environment that provide or support behaviors of an animal (e.g., a human being) that are measured not on standard scales and measurement units but "relative to the posture and behavior of the animal being considered" (Gibson, 1979). Cosco offers a practical application applied by this research: "the concept of affordance can be used to analyze similarities and differences among behavior settings by describing physical attributes or qualities of behavior setting components that offer specific behavioral responses" (Cosco et al., 2010).

Observations were conducted in spring 2015 while school was in session and when the weather was optimal for outdoor activity. A total of 12,520 users were recorded during the observations ($n = 210$) throughout the 3 parks ($n = 70$ each), with 2 rotations of observations per period. Of the recorded users, 1 was recorded who used a wheelchair in the park area of Comparison I. There were no observed participants in the playground areas with discernible disabilities. The 2 rotations were then averaged, leading to a mean number of 6,260 observed subjects in 210 observation periods.

Primary Aim: Universal Design in Play Environments

The total number of users are reported in Table 4, given as the number of users for all parks combined and as a breakdown into users per park and per observation. In all of the parks, 54% of the use was in the Park Zones. In Comparison I and Comparison II, over 60% of their use took place in the Park Zones while the Case had only 34%.

The inverse was seen in the Playground Zones where the Case, which used UD, had 66% of park use and Comparison I and Comparison II, which

Table 4. Summary of Total Observed Users by Park by Zone

	Total Users	Entire Park (All Zones) Mean (SD)[1]	R	Park Zones Mean (SD)[1]	%[2]	R	Playground Zones Mean (SD)[1]	%[2]	R
All Parks (n = 210)	6,260.0	29.8 (24.6)	1–99	16.1 (18.4)	54	0–91	13.7 (12.8)	46	0–86
Case (UD) (n = 70)	2,089.5	29.9 (24.7)	1–99	10.3 (15.2)	34	0–63	19.6 (16.6)	66	0–86
Comp I (AD) (n = 70)	2,209.0	31.6 (26.0)	1–98	19.4 (18.8)	62	2–76	12.1 (10.7)	38	0–46
Comp II (AD) (n = 70)	1,961.5	28.0 (23.3)	2–98	18.7 (19.9)	67	1–91	9.4 (7.3)	33	0–28

[1] Mean users per observation (standard deviation).
[2] Percent of observed use per park.
R = Range.

Table 5. Overall Analysis of Users per Observation Period using ANOVA

	Users per Observation Period: Mean(SD)					
	n	Case (UD)	Comp I (AD)	Comp II (AD)	F (2 d.f.)	p
Entire Park (TA 1–8)	70	29.9 (24.7)	31.6 (26.0)	28.0 (23.3)	0.36	0.700
Park Zones (TA 1–4)	70	10.3 (15.2)	19.4 (18.8)	18.7 (19.9)	5.56	0.004
Playground Zones (TA 5–8)	70	19.6 (16.6)	12.1 (10.7)	9.4 (7.3)	13.32	0.001

applied AD, accounted for 38% and 33%, respectively, of park use. This gives preliminary support to the hypothesis that UD has a positive effect on playground use. The lower level of Park Zone activity in the Case indicates that park use does not contribute to the higher playground activity level in the Case.

Analysis of variance (ANOVA) modeling was done to estimate the variance in the numbers of observed users between each of the three parks in the study. In the Entire Park (TA 1–8), the users per observation in the Park and Playground Zones combined showed no significant differences ($F = 0.36$, $P = 0.700$) between overall use in the three parks (Table 5). Use in the Park Zones (TA 1–4) showed Comparison I and Comparison II to have higher mean numbers of users per observation period, nearly double those of the Case. The bivariate test using ANOVA ($F = 5.56$, $p = 0.004$) showed significant differences in the means for Park Zones between the Case and the Comparisons.

The mean number of users in the Playground Zones (TA 5–8) of each park showed that the Case had substantially higher use in its playgrounds than Comparison I or Comparison II ($F = 13.32$, $p = 0.001$). This result supports the hypothesis that playgrounds designed using UD are more popular than those with AD (Acock, 2008). User counts were further evaluated based on the number of play components (climbers, slides, play panels, etc.) and the play surface area square footage, which has been shown to affect usage (Cohen et al., 2020). The 2010 ADA Standards for Accessible Design also evaluate playground size using the number of play components (United States, 2010). Using these measures, the Case has 40 play components with 6,400 square feet (s.f.), Comparison I has 41 play components, with 7,900 s.f., and Comparison II has 31 play components, with 5,700 s.f. Even taking into account the difference in the number of play components, the mean number of users per play component is nearly

Table 6. Analysis of Users Across the Three Parks using ANOVA

		Mean Users per Observation Period:				
	N	Case (SD)	Comp I (SD)	Comp II (SD)	F (2 d.f.)	p
Users per Play Component*	70	0.49 (0.41)	0.30 (0.26)	0.30 (0.23)	8.70	0.001
Users per 1,000 Square Feet*	70	3.1 (2.6)	1.5 (1.4)	1.6 (1.3)	15.00	0.001

* Use in Playground Zones (TA 5-8) only, n = 70.

40% greater in the Case than in the Comparisons. Table 6 shows calculations of mean users per play component and users per 1,000 s.f., and the ANOVA results show the statistical significance of the differences across the 3 parks. Significant support for the hypothesis was found in higher numbers of users per play component ($F = 8.70$, $p = 0.001$) and higher numbers of users per 1,000 s.f. ($F = 15.00$, $p = 0.001$) in the Case playgrounds, which used UD, versus the Comparison playgrounds.

We also evaluated the observation data based on the 5 observation periods, weekday versus weekend day use, weather conditions, and temperatures (Appendix Table A.1). Data analysis through ANOVA showed the same pattern of higher use in the playground zones of the Case versus Comparison I or Comparison II. ANOVA showed a positive role of UD design as reflected in the higher use in the Playground Zones of the Case compared to the Comparisons.

Further estimation through regression analysis (multivariate) was used to account for potential confounding factors, including weekend/weekday, time period, temperature, and weather. Several regression models for count variables were evaluated. The analysis found Zero Inflated Negative Binomial Regression (ZINB), a derivative of the Poisson Regression Model (PRM), the best fit for this research based on a non-standard bell curve and many early morning observations showing zero users (Long & Freese, 2014). Therefore, ZINB was run in STATA on the dependent variable of playground users with the independent variable, UD, and the control variables of weekend, time period, temperature, and cloud cover.

The results of ZINB (Appendix Table A.2) showed that the independent variable UD had the greatest impact on the dependent variable (the number of playground users), with a reported 84.1% positive change when the playground environment conforms to the design principles of UD ($p < 0.001$). Weekend use was attributed to a 40.3% increase in the number of playground users ($p = 0.005$). Analysis using ZINB supports the hypothesis that the presence of UD in playground environments has a positive impact on use.

Secondary Aim: Park Amenities, Affordances, and PA

Place-based recording of momentary park and playground use allows for the greater specification of where and how people use the facilities. The TAs in each park are grouped into Park Zones and Playground Zones, with each of the Zones being divided into 2 active TAs and 2 passive TAs to analyze the location of users relative to the amenities and affordances in behavior analysis (Cohen et al., 2020; Cosco et al., 2010; Graham et al., 2021; McKenzie et al., 2006; Stanton-Chapman et al., 2018; Talarowski et al., 2019). In this analysis, use is recategorized as Total Park in the 3 parks combined and divided into 10 different affordance categories, 4 in the Park Zones and 6 in the Playground Zones. The use of METs derived from the momentary analysis of SOPARC compliments overall use and percentage of PA among users and has been well-established in public health research. This analysis uses a definition of 1 MET for Sedentary and 4.5 METs for Active. The active rating is a hybrid between walking or low PA (3 METs) and moderate to vigorous PA (6 METs) (Ainsworth et al., 2011; Cosco et al., 2010; McKenzie et al., 2006; Van Dyck et al., 2013).

The use of park amenities was evaluated and ranked as shown in Figure 7 (Appendix Table A.3). In the Park Zones, the three highest-use areas were

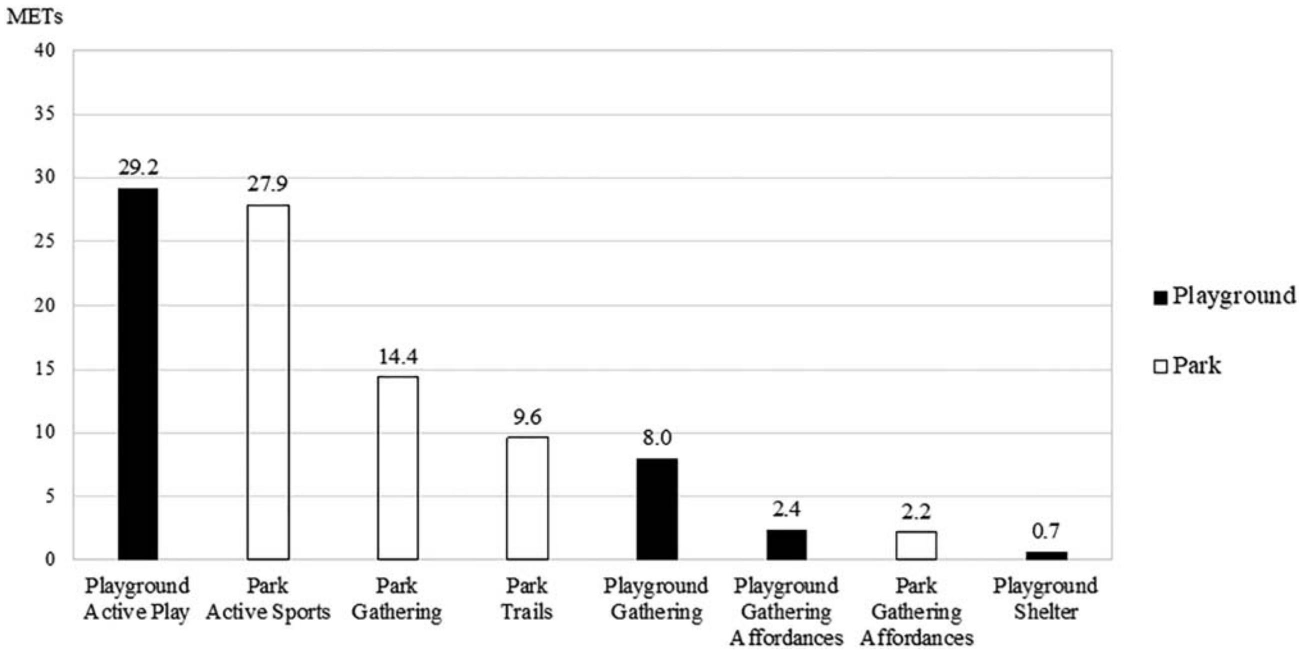

Figure 7
Percent use by affordance. Graphic by Jiwoon Jeong.

the Park Sports Active (27.9%), Park Gathering (14.4%), and Park Trails (9.6%), ranked the second, third, and fourth overall. In the Playground Zones, the active areas of the Play Surfacing, the Play Structure, and the Swings were combined to make the Playground Active Play Area, making up 29.2% of park use, the highest used area in the park. The high comparative levels of use in the formal playground areas are consistent with other findings comparing play area utilization and PA with other areas in recreational open spaces (Anthamatten et al., 2014; Cohen et al., 2020). Use of the Shelter in the Case was only 0.7% of total park use, which is the lowest in all of the areas. The presence of the shelter was considered potentially problematic, but the very low observed use of 0.7% suggests its minimal impact on actual use.

Evaluation of METs is based on METs per observation and METs per user in each affordance area. METs per observation by affordance area are shown graphically in Figure 8 (Appendix Table A.3). The Playground Active Areas, combining the Play Structure (12.0), Swings (6.5), and Play Surfacing (15.3), had the highest overall MET score, with 33.8 METs on average per observation. From the Park Zones, the Park Active Sports Areas generated the largest MET value, with 25.7 METs per observation.

The location-specific recording system, with its graphic output, illustrates use patterns showing the clustering of uses around the active sports areas, on trails, and within the playground on the site furnishings and on play elements. An example of the graphic output of total use patterns during a representative day in the park overall and in the playground areas is shown in Figure 9. The symbols are consolidated from the original 16 categories into 4 symbols depicting children and non-children (mostly adults) as either active or sedentary for consolidated presentation. Further analysis could be the subject of future work.

The park plan in Figure 10 shows PA levels in the use areas as defined by affordance. In the Park Zones, only the Park Trails showed a percent of physically active users (96.8%) above the overall mean of 64.3% across all three parks. Park Trails had the highest percentage of physically active users among all the affordance areas. The Playground Zones showed higher percentages of physically active users, with all four of the Playground Zone affordance categories higher than the mean for all three parks. The breakdown was as follows: Gathering Areas (66.4%), Play Structure (92.1%), Swings (67.1%), and Play Surfacing (83.1%).

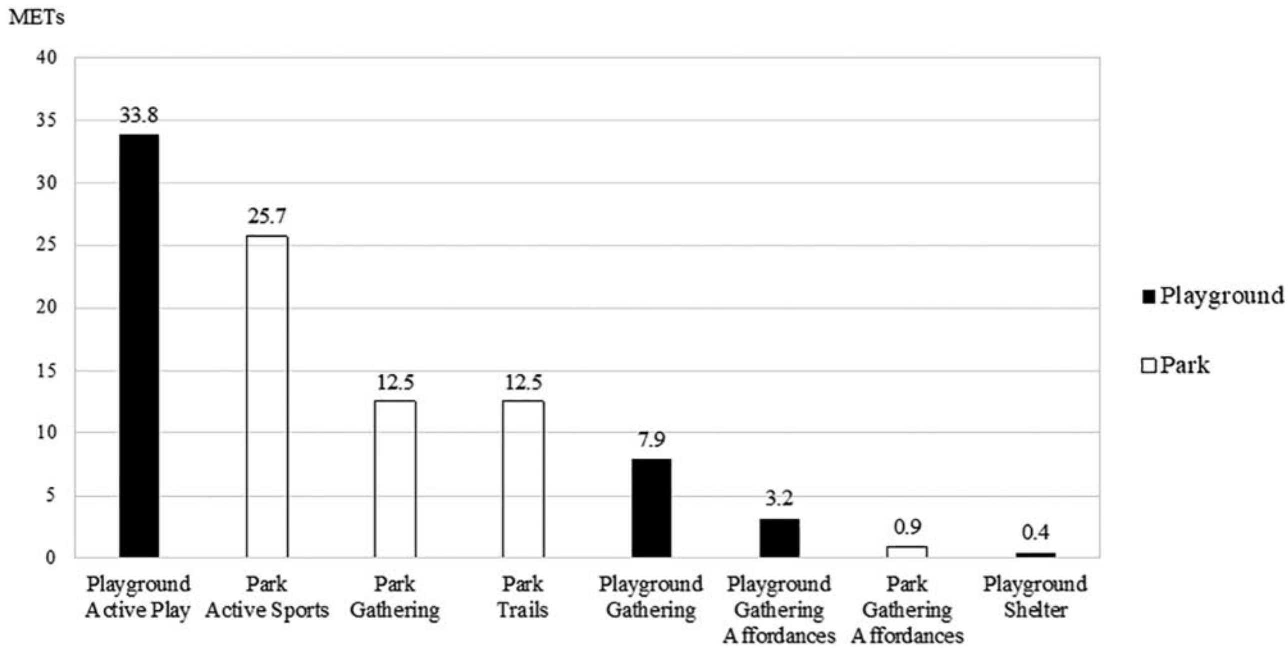

Figure 8
METs per observation by affordance area. Graphic by Jiwoon Jeong.

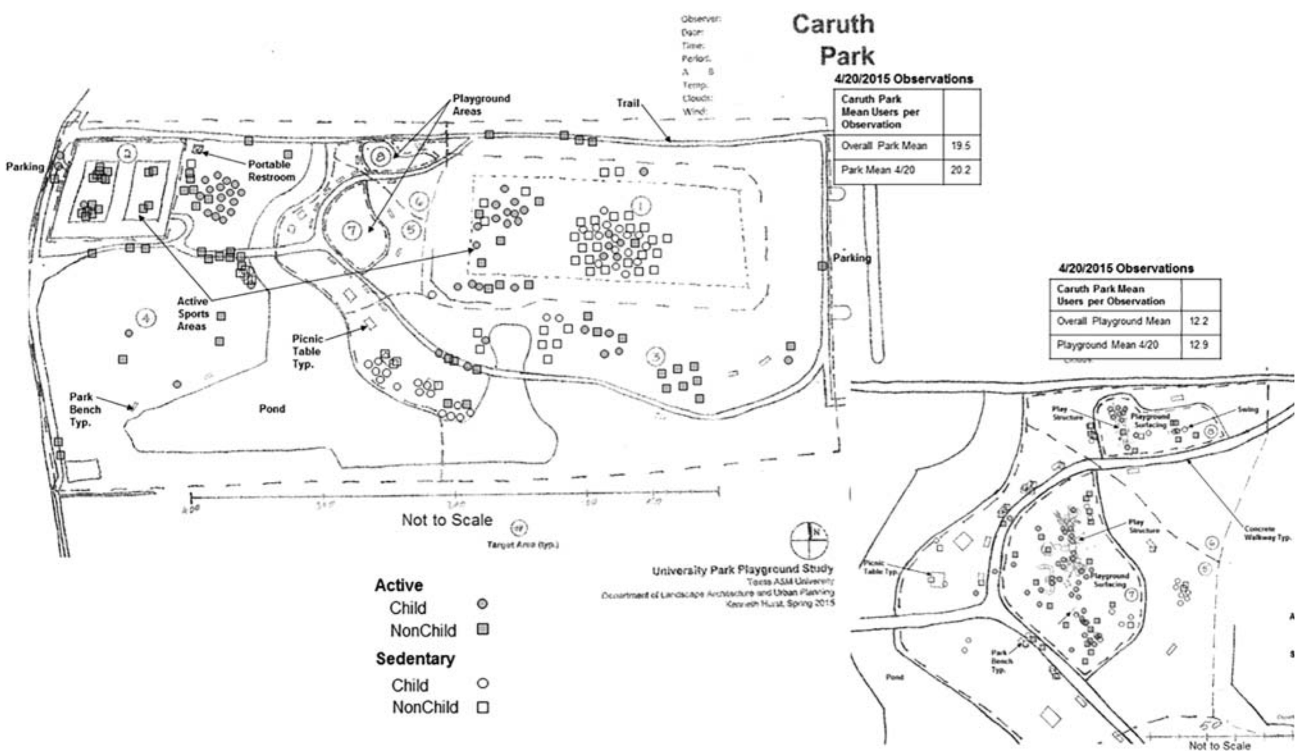

Figure 9
Comparison II total use on an average representative day: 04/20/2015. Graphic by first author.

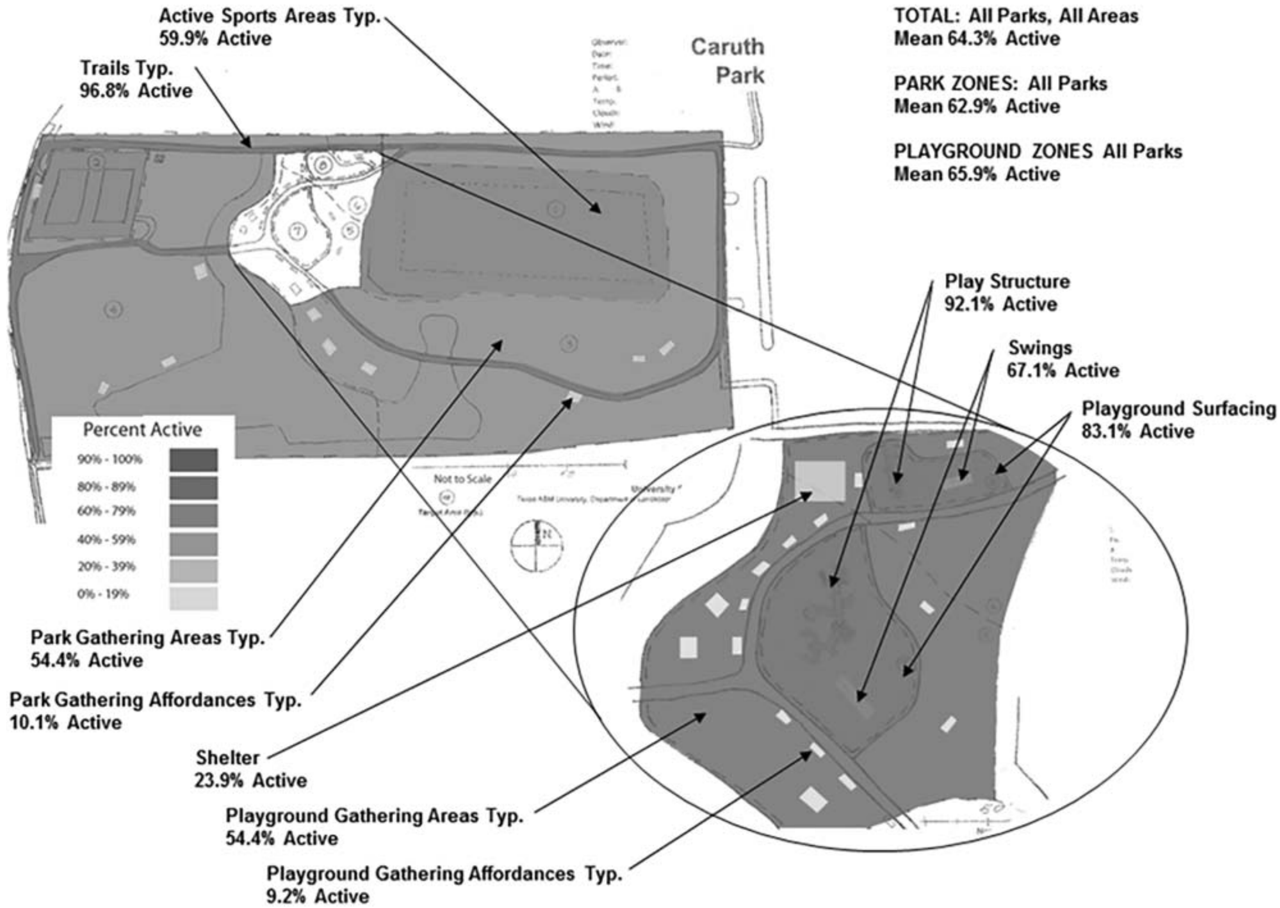

Figure 10
Overall percent of physically active users expressed on Comparison II plans. Graphic by first author.

DISCUSSION

The significance of the higher use in the Case playground gives support to the hypothesis that UD in play environments can lead to higher use. Analysis of the data shows substantively higher use levels in the Case Playground Zones, with the mean use 62.0% higher than the Comparison I playground and 108.5% higher than the Comparison II playground (Table 3). The ANOVA analysis shown in Table 4 reports a significant difference between the means ($p = 0.001$) in the Playground Zones. Multivariate analysis of the data applying ZINB confirms that UD contributed 84.1% of the increased use observed in the playground environment ($p < 0.001$) in the Case. Evaluation of use in the Park Zones has a significant inverse relationship, showing substantially lower use of the Park Zones in the Case. This result undermines arguments for potential contextual influence from the overall park users. Also, very little about the physical feature variables shown in Table 1 would suggest that any of them confer an advantage to the Case playground.

Analysis of use per playground play component and playground size (use per square foot) also shows higher use levels at the Case playground. Use on weekends versus weekdays, use during the different observation periods, and use in different weather conditions and temperatures show some differences in overall patterns, yet they also confirm higher use at the Case playground than at the Comparisons. These evaluations further support the hypothesis that the Case playground with UD generates more use than the Comparison playgrounds with AD.

In the parks as a whole, people using the parks in this study were more active than sedentary (64.3% were active). While the Park Zones had the highest percentage of use (54.1%), the combined playground active areas contributed a greater overall percentage to park use than the active sports areas (29.2% vs. 27.9%) and had more users per observation (8.7 vs.

8.3). The trails had the greatest percentage of users who were active (96.8%), followed by the three active playground areas (67.1% to 92.1%). Active sports areas had lower percentages of active users (59.9%) than the park averages as a whole (64.3%). When measuring METs for energy expenditure, the gap between the active playground areas (33.8 METs) and the active sports areas (25.7 METs) is substantial.

The combination of place-based graphic recording methods and the established momentary tabular protocols in SOPARC resulted in an enhanced methodology capable of recording participants in place in association with specific affordances and behavior settings and allowed for the adaptation of the variables to meet specific study needs (Cosco et al., 2010; McKenzie et al., 2006). By combining methodologies, the instrument can focus on the role affordances play when investigating contributions to PA and use by people in a variety of demographics in both existing facilities and post-occupancy evaluations. This research helps fill the knowledge gap in the existing literature by addressing the more specific questions about the impact specific amenities and their associated affordances have on use and their influence on PA levels in public outdoor open spaces (Chow et al., 2016; Cohen et al., 2020; Colabianchi et al., 2011; Costigan et al., 2017; Graham et al., 2021; Kaczynski & Henderson, 2008; Koohsari et al., 2015; Moore & Marcus, 2008; Mowen et al., 2013; Perry et al., 2018).

Limitations

The research was conducted within a single city and state, within three parks in homogeneous neighborhoods, and using a single specific class of playground equipment. The measurement instrument focused on the physical dimension of accessibility and was therefore limited in scope to physical accessibility. Generalizability is limited by its scope and by the low sample size of the number of parks and the single city. The addition of more subject parks and playgrounds would contribute to strengthening the external validity or generalizability. The study was conducted only in the spring of the year during a distinct period while school is in session. Use patterns may change when school is not in session and at other times of the year, with seasonal differences further impacting generalizability. The ZINB model does not account for the inherent data issues with repeated measures (multiple observations from the same locations) that result in the risk of making Type 1 Errors (i.e., finding false relationships). However, given the highly significant result for the UD variable ($p < 0.001$), we believe it is still likely to hold its significance despite this concern. Further, because the IRB-exempt status of this passive observational study did not allow for contact with participants, the age of observed participants was estimated, and the precise knowledge of a participant's age, either child or otherwise, was unknown. Without participant contact, variables measuring participant attitudes and preferences including experiential accessibility could not be measured. In addition, the racial status of the observed users could not be captured reliably without participant contact and was therefore not used.

CONCLUSIONS

This research has sought to generate support for UD in playground environments by documenting the increased use of playgrounds designed applying UD for people of all abilities, including those with a range of physical and cognitive disabilities along with those who are not living with disabilities. From the inception of ADA, adherence to AD minimums has always been an important consideration. Play environments that were built applying UD principles, surpassing the minimums of the ADA Standards, have been promoted around the country and are becoming more commonplace as the ADA Standards become better understood and accepted (Lynch et al., 2018; Moore & Cosco, 2007; Moore et al., 2022). Research increasing support for UD may help reduce resistance from funding sources to commit the additional resources involved in the costlier elements that have often been experienced when proposing UD in design to accommodate what was often thought of as only "a small minority of users." Another popular opinion this research seeks to confront is that those play areas built for accessibility are only for those living with a disability (Perry et al., 2018; The Universal Design Project, n.d.) and are accompanied by a lower level of challenge in play and therefore less fun to play in for children without disabilities.

Evaluation of the Primary Aim of the attractiveness of UD in play environments showed that the mean use per observation in the UD playground was 82% higher than those comparisons designed with AD. Results appear to offer sufficient supporting evidence that UD is a positive contributor to increased playground use and therefore more attractive to all users in the general public.

Demonstration of the value of UD as an explicit design element responds to one dimension of the need for research in specific physical elements of the outdoor environment relative to use and PA (Colabianchi et al., 2011; Kaczynski & Henderson, 2008; Lynch et al., 2018; Moore et al., 2022). These findings, focused on physical elements drawing users to the park, complement studies on play environments that discuss how exposure to nature results in getting children outdoors so that they can become more active and enjoy the accompanying health benefits (Kerr, 2007; McCreary et al., 2012; Mowen et al., 2013).

This research and some of the accompanying documentation on specific physical park elements give support to playground advocates when approaching policymakers for funding more expensive UD facilities. Playground advocates may be members of the general public striving to have playground facilities built, or they may be internal school and park professionals competing with other public interests for funding. This research was initiated to offer supporting evidence for the greater implementation of UD facilities by demonstrating their value to the public as a whole.

The Secondary Aim of the study was to explore PA in association with specific activity areas and affordances. The body of evidence is growing on the impact the built environment has on public health and PA, which can lead to policies in municipalities, schools, and public park departments aimed at promoting public health through PA (Floyd et al., 2008; Henderson et al., 2001). The research and location-specific observation methodology presented here can serve to build evidence of the contribution of park use to public health. Evidence of the impact parks have on urban wellness can inform better consideration in the budgeting process for parks and public open space. Facilities conceived and implemented through these practices and policies can make a positive contribution to the overall health and welfare of the general public, impacting all people regardless of abilities (Colabianchi et al., 2011; Kaczynski et al., 2008; Valentini & Morosetti, 2021).

Some outcomes of the secondary aim showed that in contrast with many of the programmed activities in the parks as a whole, the unprogrammed active and passive Playground Zones attract 46% of park use in approximately 8% of the parks' land area. It is interesting to note that the Combined Active Playground Areas generated more PA as unprogrammed space than did the actively programmed Active Sports Areas. These findings suggest the contribution of playgrounds to overall park PA may be greater than commonly thought. Another outcome was the unexpected finding that adults constituted 43% of the recorded users in the study's Playground Zones. This suggests that a whole environment approach to designing playgrounds, making them comfortable for adults and children alike, may increase playground use by making them more attractive to those accompanying children.

This study represents an evolution of SOPARC, an established system that is well-used and documented for use in behavioral evaluation in outdoor park environments. The momentary observation methodology of SOPARC was enhanced with the location-specific graphic recording technique, which can be used as an effective instrument to evaluate existing facilities or interventions. It allows for analyzing specific features, elements, and affordances, bringing defensible evidence to design practice (Cohen et al., 2020; Cosco et al., 2010; Hunter et al., 2015; McKenzie et al., 2006; Sallis et al., 2015; Talarowski et al., 2019). The research literature has also identified gaps in evidence-based research on specific physical elements of the open space environment and their influence on use and PA, with a need for specific measures and tools to examine the influence specific open space elements have on use and PA levels (Colabianchi et al., 2011; Kaczynski & Henderson, 2008; Koohsari et al., 2015). Competition for public funding is often fierce, and documentation of the contribution parks and other public open spaces make toward increasing PA and population health can lead to policies in support of public open space, taking advantage of the low cost of parks versus the high cost of health care (Cohen & Leuschner, 2017; Colabianchi et al., 2011; Kaczynski et al., 2008; Valentini & Morosetti, 2021).

Methodologies in the study can be easily adaptable to various populations, including residents of low-income neighborhoods and facilities serving children, seniors, and those with disabilities. Behavioral study of public open space can lead to the substantiation of policies and design practices benefiting the well-being of people from all walks of life and of all ages, races, genders, and abilities. More observations could be done in park environments on state, national, or global levels to see if the pattern exists on a broader scale in a greater diversity of environments. Observations in more and different parks could also include a diversity of racial and socioeconomic demographics evaluating the effects those variables may have. These additional observations could also be extended into different times of the year and different weather patterns. Expansion of the observations to a larger number of parks may lead to additional statistical analyses and more generalizable findings. Adding more research settings can make multilevel modeling possible where its application was limited in this study by the low number of settings (i.e., three parks in one city). The addition of park user and opinion data gathered using intercept interviews could complement this study's quantitative observation data by enriching the depth and interpretability of the findings with more precise data on user characteristics, reasons for using the parks and playgrounds, distances traveled, qualities of the experience, and so forth (Little, 2020; Veitch et al., 2021). Further analyses of the data in Geographic Information System (GIS) have the potential to uncover additional spatial relationships, which can include the identification of specific nodes or hot spots that attract high levels of use in park and playground environments.

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APPENDIX

Table A.1. Analysis of Users Across the Three Parks using ANOVA

	Mean Users per Observation Period:					
	n	Case (SD)	Comp I (SD)	Comp II (SD)	F (2 d.f.)	p
Weekday*	50	18.6 (15.3)	10.7 (9.1)	9.1 (6.7)	10.74	0.001
Weekend day*	20	22.0 (19.6)	15.8 (13.3)	9.9 (8.7)	3.43	0.039
7:30 am Observation*	14	0.5 (0.7)	0.3 (0.7)	0.8 (0.9)	1.58	0.220
9:30 am Observation*	14	22.8 (19.9)	13.5 (6.4)	7.6 (5.2)	5.31	0.009
12:30 pm Observation*	14	26.8 (16.4)	16.6 (11.6)	9.8 (4.4)	7.27	0.002
3:30 pm Observation*	14	30.6 (12.7)	21.2 (11.2)	18.4(6.0)	5.25	0.010
6:30 pm Observation*	14	17.3 (6.1)	9.0 (4.9)	10.1(5.2)	9.55	0.001
Clear**	91	21.6 (16.5)	14.3 (10.7)	10.4 (8.1)	6.48	0.002
Partly Cloudy**	27	18.8 (9.4)	10.0 (7.3)	8.0 (5.7)	5.07	0.015
Cloudy**	89	18.3 (18.8)	11.0 (11.4)	8.5 (6.8)	4.36	0.016
Misting Rain**	3	6.0 (0.0)	1.5 (0.0)	12.5 (0.0)		
Temperature <60°F**	16	11.8 (13.2)	9.3 (12.9)	1.3 (1.5)	1.35	0.293
Temp. >=60°F, <70°F**	44	11.1 (13.3)	7.4 (8.4)	6.5 (6.7)	0.89	0.412
Temp. >=70°F, <80°F**	101	20.3 (17.2)	13.6 (11.1)	10.5 (7.2)	5.21	0.007
Temp. >=80°F**	49	27.4 (14.5)	14.8 (10.3)	11.8 (6.9)	9.57	0.001

* Use in Playground Zones (TA 5–8) only, n = 70.
** Use in Playground Zones (TA 5–8) only, n = 210.

Table A.2. ZINB Regression: Percentage Change Independent and Control Variables

	b	z	P>|z|	%	%StdX	SDofX
UD	0.6102	5.503	<0.001	84.1	33.4	0.473
Weekend	0.3386	2.840	0.005	40.3	16.6	0.453
Time Period	0.1252	2.319	0.020	13.3	19.4	1.418
Temperature	0.1462	1.868	0.062	15.7	13.4	0.857
Cloud Cover	–0.1684	–2.860	0.004	–15.5	–14.9	0.958
Constant	–7.6628	–4.495	<0.001	—	—	—

b = raw coefficient.
z = z-score for test of b = 0.
P>|z| = p-value for z-test.
% = percent change in the expected count for a unit increase in X.
%StdX = percent change in the expected count for SD increase in X.
SDofX = standard deviation of X.

Table A.3. Use and PA in METs by Affordance

	Users	Users /Obs	% of TOTAL	% Active	METs /Obs	METs /User
PARK (TA 1–8)	6260	29.8	100.0	64.3	96.9	3.3
Park Zone (TA 1–4)	3384.5	16.1	54.1	62.9	51.6	3.2
Gathering Areas	903.5	4.3	14.4	54.4	12.5	2.9
Gathering Affordance	139	0.7	2.2	10.1	0.9	1.3
Active Sports Areas	1743.5	8.3	27.9	59.9	25.7	3.1
Trails	598.5	2.9	9.6	96.8	12.5	4.3
Playground Zone (TA 5–8)	2875.5	13.7	45.9	65.9	45.3	3.3
Gathering Areas	500	2.4	8.0	66.4	7.9	3.3
Gathering Affordance	507	2.4	8.1	9.2	3.2	1.3
Shelter	44	0.2	0.7	23.9	0.4	2.0
Play Structure	596	2.8	9.5	92.1	12.0	4.3
Swings	404.5	1.9	6.5	67.1	6.5	3.4
Play Surfacing	824	3.9	13.2	83.1	15.3	3.9